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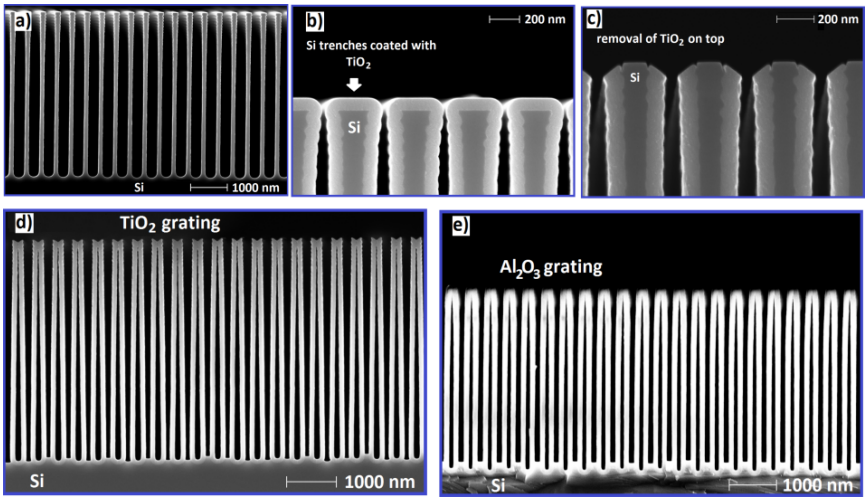
# Fabrication of $TiO_2$ and $Al_2O_3$ High Aspect Ratio Nanostructured Gratings at Sub-Micrometer Scale

Evgeniy Shkondin[a,b], Jonas Michael Lindhard[b], Mikkel Dysseholm Mar[b], Flemming Jensen[b], Andrei Lavrinenko[a]

[a]Department of Photonics Engineering Technical University of Denmark, DK-2800 Kgs. Lyngby; [b]Danish National Center for Micro- and Nanofabrication (DANCHIP), DK-2800 Kgs. Lyngby. eves@fotonik.dtu.dk

Metal oxides such as $TiO_2$ and $Al_2O_3$ can be used for many different fields of applications including photovoltaics, MEMS technology, and high quality dielectrics for DRAM trench capacitors [1]. There is a great need to develop a reliable and reproducible way to pattern such materials on nanoscale. Successful attempts to fabricate and measure 2D photonic crystal based on hexagonal pattering of $TiO_2$ nanopillars with the aspect ratio of 7.5 have been reported [2]. In this work we present a method of pattering $TiO_2$ and $Al_2O_3$ nanogratings with a high aspect ratio of up to 20 on a silicon substrate.




Figur 1. Fabrication of $TiO_2$ and $Al_2O_3$ nanogratings. a) Silicon trenches. b) $TiO_2$ coverage using ALD. c) Selective opening of $TiO_2$ top part. d)-e) Isolating $TiO_2$ or $Al_2O_3$ by removing the silicon core leads to the formation of nanostructured gratings.

As a starting point deep UV lithography was used to pattern resist on 2 $cm^2$ scale chips. Thereafter deep reactive ion etching was used to fabricate 4.5 µm deep silicon trenches with a period of 400 nm (figure 1a). The silicon trenches have been coated using atomic layer deposition (ALD) with 100 nm thick $TiO_2$ or $Al_2O_3$ at 150°C (figure1b). The ALD coatings form nanostructured gratings but in order to isolate the $TiO_2/Al_2O_3$ trenches it is necessary to remove the silicon core (figure 1b). By introducing a chlorine plasma flow using inductively coupled plasma etching, it is possible to remove the top part of the $TiO_2$ coating; meanwhile the sidewalls and the bottom remain unharmed (figure 1c). For removal of the $Al_2O_3$ top part coating, the chlorine plasma was supported by a $BCl_3$ gas flow. The selective removal of the $TiO_2/Al_2O_3$, top part provides access to the silicon core between the ALD grown sidewalls. An $SF_6$ plasma removes selectively silicon without any observable influence on $TiO_2$ or $Al_2O_3$ thus revealing a high selectivity throughout the fabrication (figure 1d-e).

Using this procedure the $TiO_2$ and $Al_2O_3$ gratings have been fabricated. We believe this approach opens the possibility to fabricate high quality epsilon–near-zero [3] and hyperbolic metamaterials [4], using this procedure.

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